

## **Background study for $\gamma + \text{jet}$ .**

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Study of a possibility of suppression of  
the background by the way of the event  
selection and an influence of the back-  
ground on the calibration.

## History

### 1 step. Studies of the background at the particle level.

D.Bandourin, V.Konoplianikov, N.Skachkov

"Jet energy scale setting with  $\gamma$ +jet events at LHC energies. Detailed study of the background suppression", JINR Preprint E2-2000-255, JINR, Dubna.

**It was shown that background can be suppressed significantly by using of the event selection: the background fraction is about 10% at the signal suppression in to 10 times for  $Pt^\gamma > 40 \text{ GeV}/c$ .**

## **2 step. Simulation of effects in setup:**

- **CMS geometry,**
- **4 T magnetic field,**
- **energy and spatial smearing**

V.Konoplianikov, V.Palichik, E.Tikhonenko,  
O.Kodolova. "Background study for  $\gamma + \text{jet}$  with  
CMSJET and CMSIM", CMS NOTE 2001(in draft).

**It was shown that geometry, field and smearing practically don't influence on the number of background events and on errors of  $\gamma - \text{jet}$  calibration.**

## **3 step. Current results**

(comparison CMSJET/CMSIM/ORCA).

- **Simulation of an electronical noise.**
- **Study of an influence of the background on the calibration at soft and hard criteria of event selections.**

# Used events with direct photons ( $\gamma + jet$ ) and background ( $jet + jet$ ) from Spring01 production

Parameters of the samples "1" – "3".

Parameter	"1"	"2"	"3"
$Pt_{min}^\gamma (GeV/c)$	20	40	100
$Pt_{max}^\gamma (GeV/c)$	40	100	200
$\hat{p}_\perp \text{ min}$	10	20	50
$\hat{p}_\perp \text{ max}$	80	200	400
No of events	50000	50000	50000

Current production has been carried out with preliminary selection at the PYTHIA level:

## Inside 4x4-region (4x4 crystals)

- should be  $e/\gamma$  with  $Pt > 5 \text{ GeV}/c$ ;
- a sum of Pt of particles:  $Pt_{4x4} > Pt_{min}^\gamma$ ;
- no hadrons with  $Pt > 10 \text{ GeV}/c$ .

## Inside $R = 0.7$ and outside 4x4-region

- any number of charged particles with  $Pt < 2 \text{ GeV}/c$ ;
- a sum of Pt for neutral + charged particles with
  - .  $Pt > 2 \text{ GeV}/c$  is  $< 20\% Pt_{4x4}$ ;
- a sum of Pt for all particles is  $< 25\% Pt_{4x4}$ .

## **Backgrounds contents.**

- ” $\gamma$  – mesons” – the photons from  $\pi^0$ ,  $\eta$ ,  $\omega$  and  $K_S^0$ ;
- ” $\gamma$  – brem” – the photons were emitted from quarks.

## **Background study levels:**

- ”**PYTHIA**” – CMSJET v.4.703 without field and energy and spatial smearing;
- ”**FIELD**” – CMSJET with field and without energy and spatial smearing;
- ”**SMEAR**” – CMSJET with field and energy and spatial smearing;
- ”**ORCA**” – CMS121 + ORCA454

# Influence of the background on the calibration

The task of calibration is to reconstruct  $Et^{jet}$  using  $Et^\gamma$ :

$$Et^{jet} = Et^\gamma$$

We have different values of disbalances:

$\Delta_S = \langle Et^\gamma - Et^{jet} \rangle_S$  – a case of signal events;

$\Delta_{S+B} = \langle Et^\gamma - Et^{jet} \rangle_{S+B}$  – a case of signal  
+ background.

**Thus background causes an error into the calibration:**

$$\Delta_{S+B} - \Delta_S$$

**Futher we shall characterize backgrounds by:**

- **a part of background events**  $B/(B+S)$ ;
- **an errors**  $\delta_{S+B} - \delta_S = (\Delta_{S+B} - \Delta_S)/Et^\gamma$ ;
- **an difference**  $\sigma_{S+B} - \sigma_S$  ( $\sigma = \text{RMS of } Et^\gamma - Et^{jet}$ ).

**For background suppression we put constraints (selection cuts) on the values:**

$\mathbf{Et}_\gamma^{isol}$  – summarized Et in the R=0.7 outside 3x3 crystals,

$\Delta\phi$  – angle between " $\gamma$ " and jet

$\mathbf{Et}^{jet2}$  – Et of the second jet

$\mathbf{Et}^{out}$  – vector sum of Et outside 3x3 crystals and outside jet

We study background with soft and hard cuts (1-7), with the simultaneous limitation on the  $\mathbf{Et}_\gamma^{isol}$ ,  $\Delta\phi$ ...

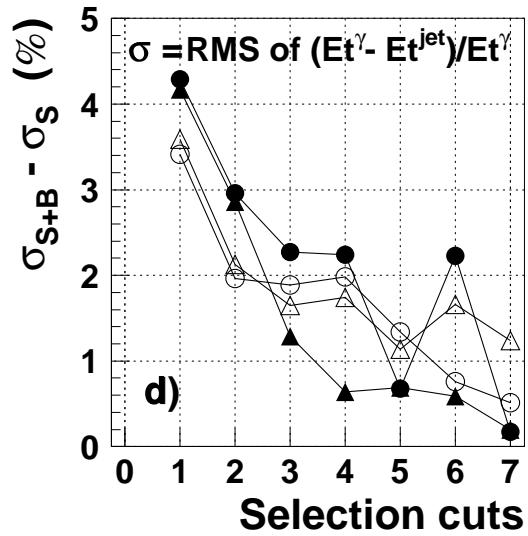
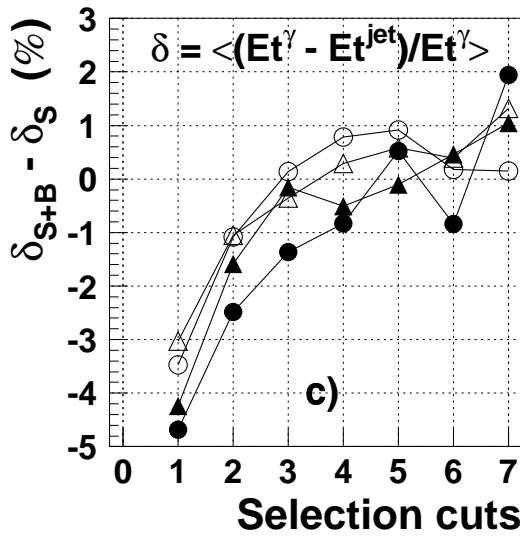
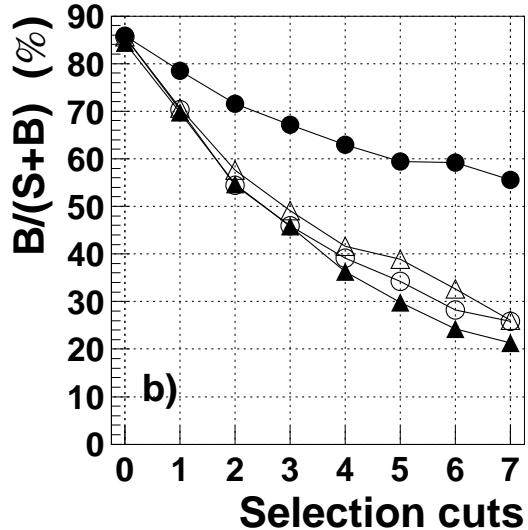
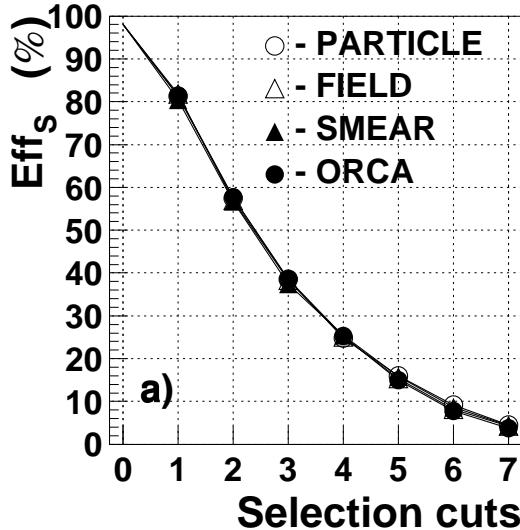
The each of the selection cuts 1 – 7 is connected with the efficiency of signal suppression ( $\text{Eff}_S$ ):

Selection cuts	1	2	3	4	5	6	7
$\text{Eff}_S$ (%)	83	60	40	27	17	10	5

We have at ORCA-level for  $Et^\gamma = 100 \text{ GeV}$ :

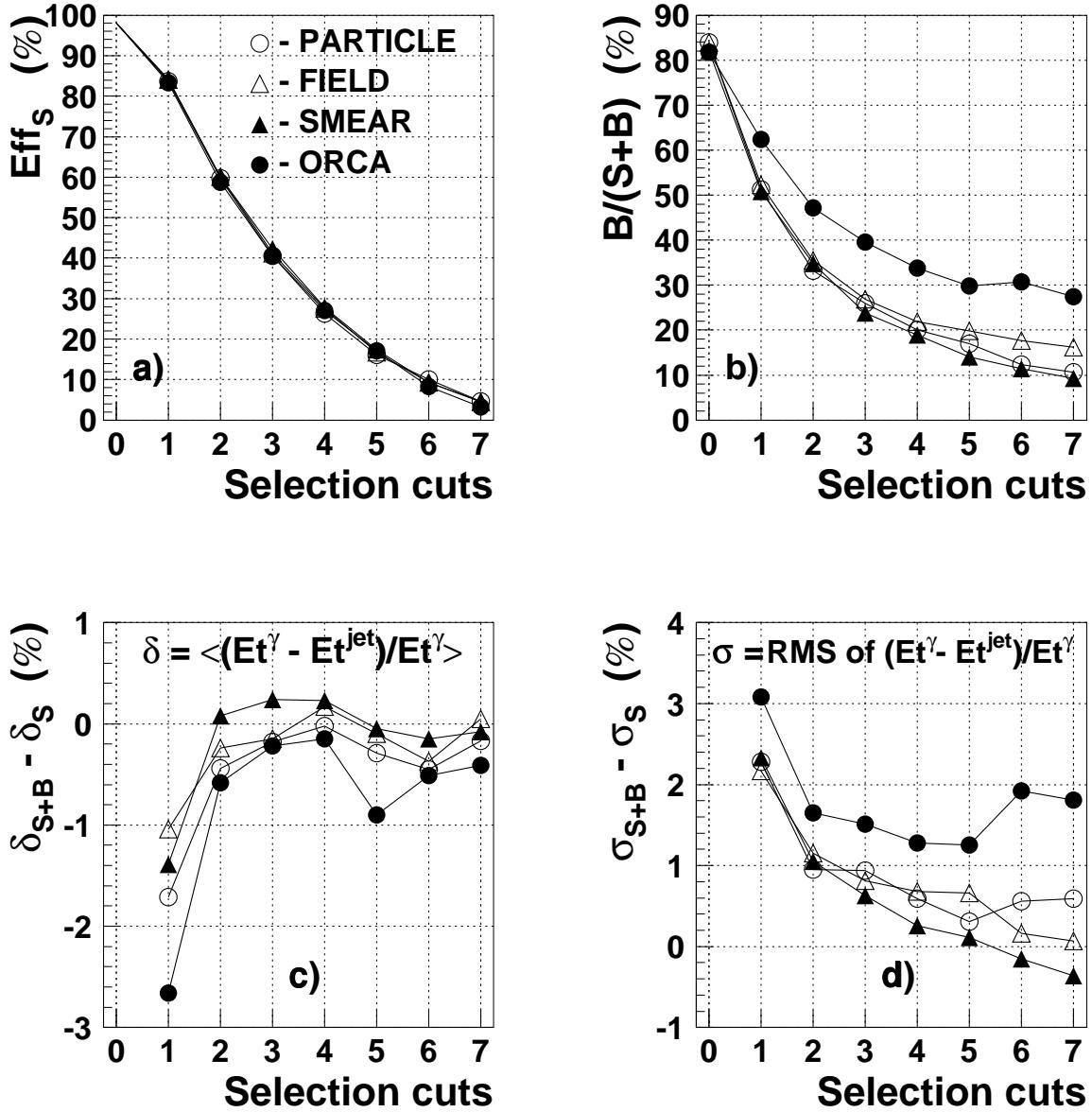
Selection cuts	1 ( $\text{Eff}_S=83\%$ )	...	7 ( $\text{Eff}_S=5\%$ )
$\mathbf{Et}_\gamma^{isol}$ max ( $\text{GeV}$ )	12	...	4
$(180^\circ - \Delta\phi^\circ)$ max	38	...	15
$\mathbf{Et}^{jet2}$ max ( $\text{GeV}$ )	40	...	15
$\mathbf{Et}^{out}$ max ( $\text{GeV}$ )	41	...	10

Case  $20 < Et^{\gamma} < 40 GeV$ .



The background at ORCA-level is equal about 60% for hard cuts (4-7) (instead 30% without noise (fig.b)). However, starting with 3-4 cuts the background leads to systematic errors of a calibration  $< 1\%$  (fig.c) and statistic errors  $< 2\%$  (fig.d). At the same time signal is suppressed in to 3 times (fig.a).

Case  $40 < Et^\gamma < 100 GeV$ .



For higher  $Et^\gamma$  the situation with background is much better. In case ORCA we have at cut 4:

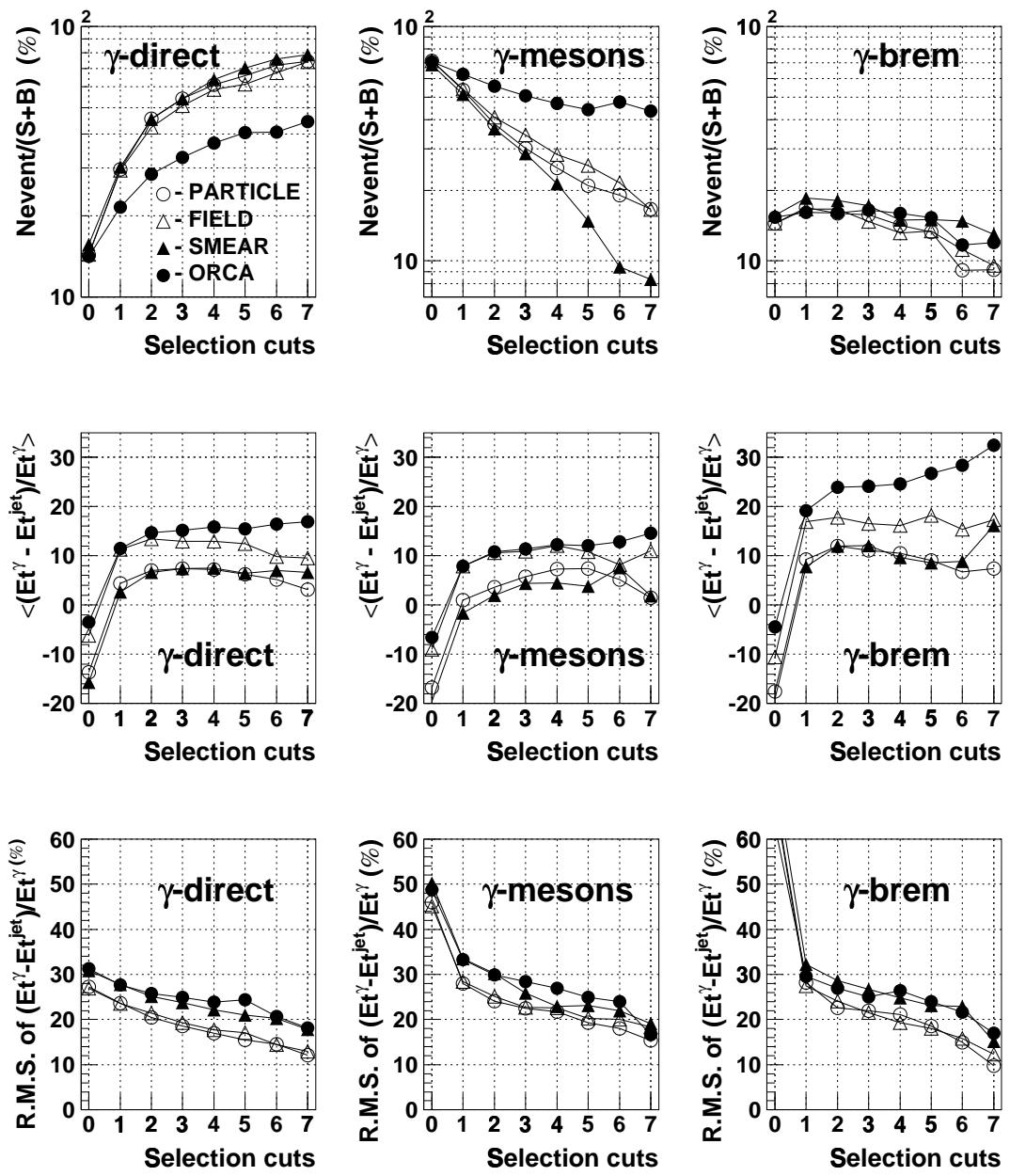
part of background  $\approx 30\%$  (fig. b)

and at cut 2 ( $Eff_S=60\%$ ):

sistematic error  $<1\%$  (fig. c)

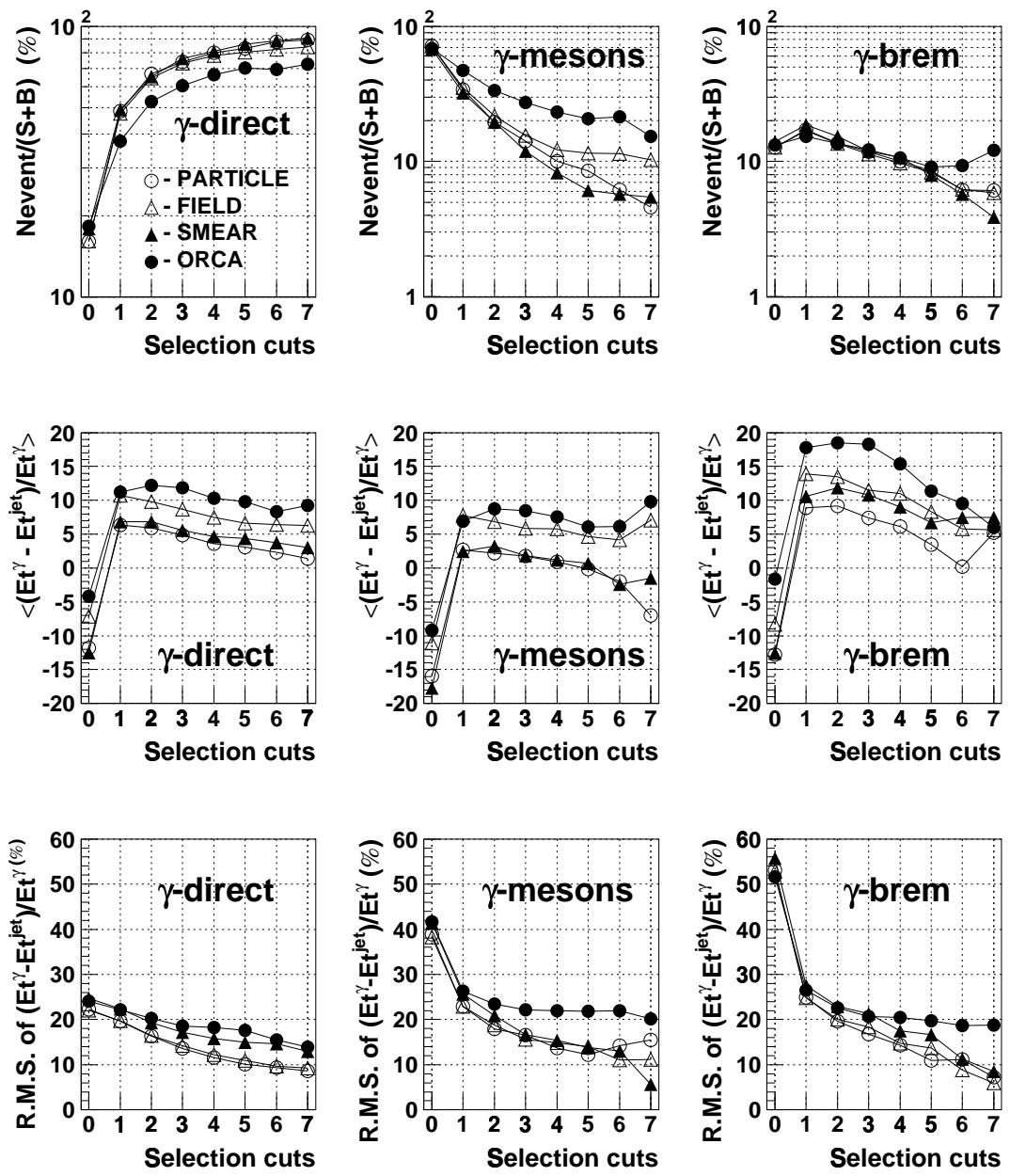
and statistic error  $<2\%$  (fig. d).

# Case 20 $< E_t^\gamma < 40 \text{ GeV}$ .



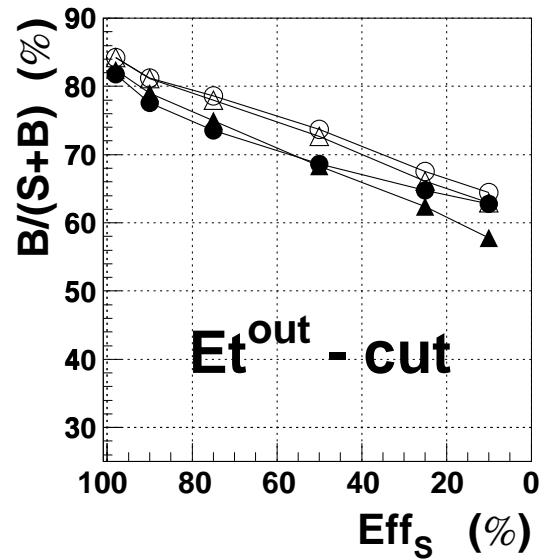
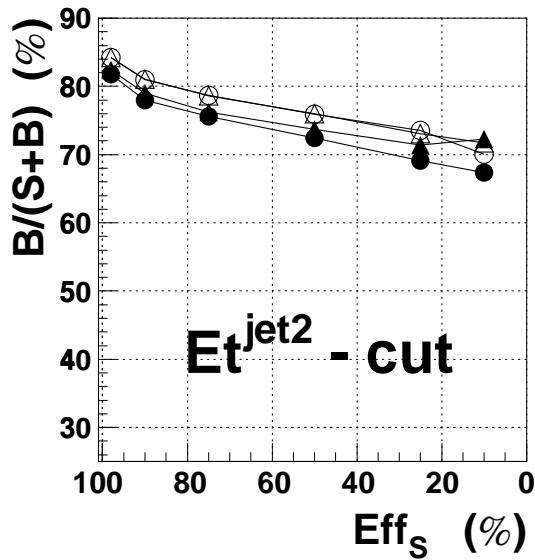
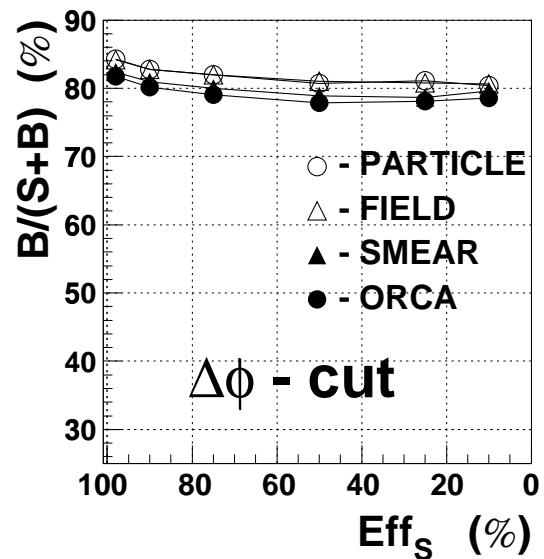
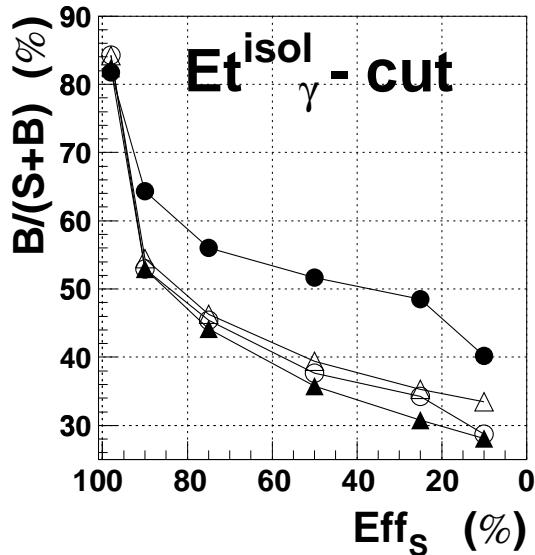
With ORCA calculation a part of  $\gamma$ -mesons is increased in to 2 times (*isolation criteria had worse performance*). A systematic error depends mainly from the  $\gamma$ -brem, having the  $E_t^\gamma$ - $E_t^{\text{jet}}$  disbalance differ than  $\gamma$ -direct.  $\gamma$ -mesons influence mainly into the statistic error.

# Case $40 < Et^\gamma < 100 \text{ GeV}$ .



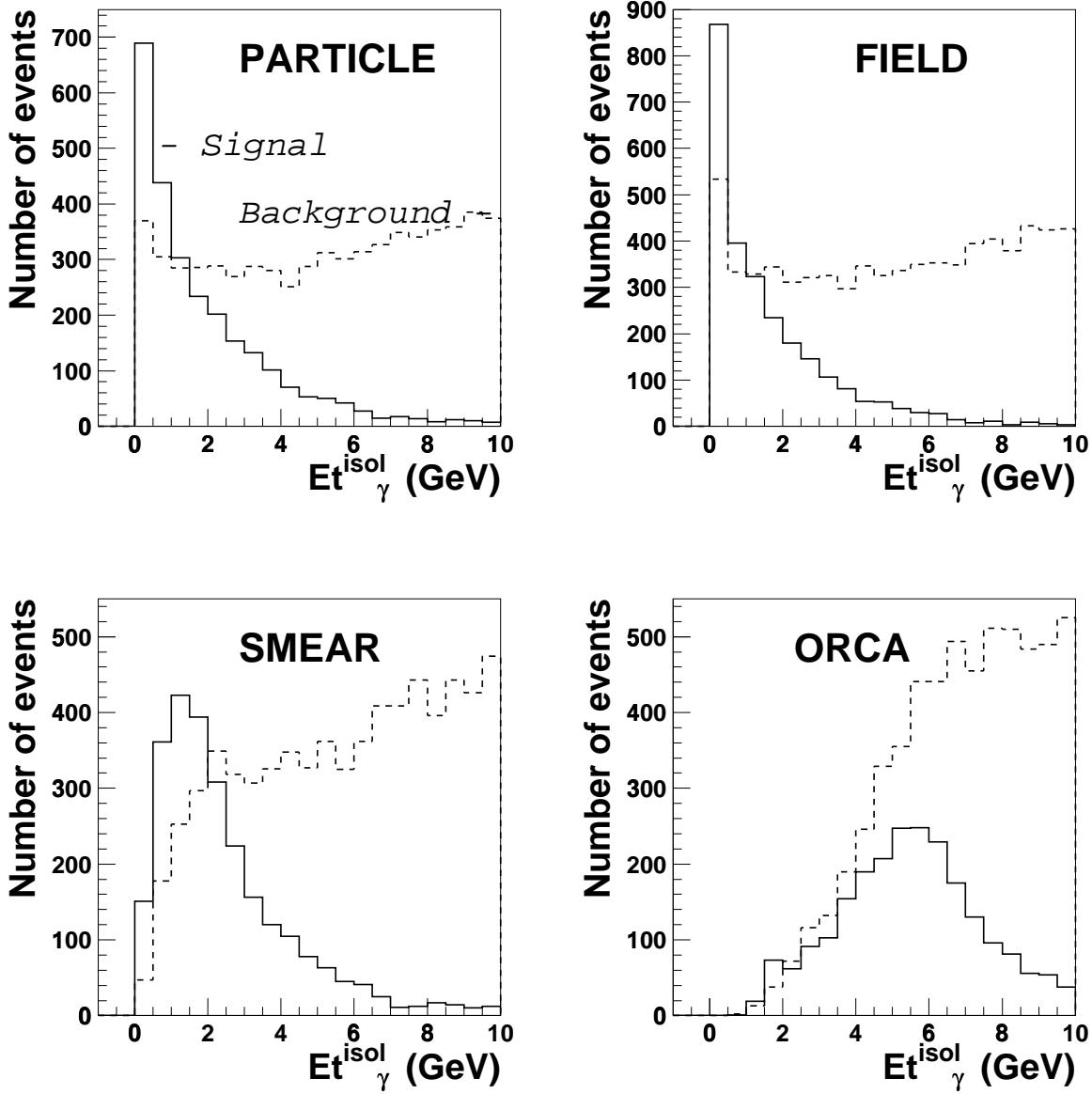
For higher  $Et^\gamma$  the situation with influence of noise on part of " $\gamma$ -mesons", systematic and statistic errors is similar.

Case  $40 < Et^{\gamma} < 100 GeV$ .



We can reduce a part of the background in the selected events by using  $\text{Et}_{\gamma}^{\text{isol}}$ ,  $\Delta\phi$ ,  $\text{Et}^{\text{jet}2}$  and  $\text{Et}^{\text{out}}$  cuts.  $\Delta\phi$ ,  $\text{Et}^{\text{jet}2}$ ,  $\text{Et}^{\text{out}}$  suppress the background at **PARTICLE**, **FIELD**, **SMEAR**, **ORCA** levels equally. But background suppression at ORCA-level by  $\text{Et}_{\gamma}^{\text{isol}}$ -cut worked worsely.

Case  $40 < Et^{\gamma} < 100 \text{ GeV}$ .



The  $Et_{\gamma}^{isol}$  distributions for both signal and background at PARTICLE, FIELD, SMEAR and ORCA levels are presented here. We can see that the signal and background separation is not good at ORCA level. This fact is the main source of the degradation of situation with background at the ORCA level.

# Conclusions

- We have used ORCA 454, which differs from CMSJET/CMSIM in digitisation, i.e. noise is included:

Parameter (GeV)	ECAL barel	ECAL endcap	HCAL
E cut to cell	<b>0.060</b>	<b>0.300</b>	<b>0.300</b>
Et noise in cone 0.7	<b>4.0</b>	<b>2.0</b>	<b>1.0</b>

- Upon taking into account the noise, the background is increased in to 2 times as a result of the worse background suppression with an isolation cut.
- However, by using of the event selection at signal suppression in to 2 times, the background leads to calibration errors less then 1-2%.
- Situation with  $\gamma$  in EB and  $\gamma$  in EE is similar.

Next step of the background study  
is taking in to account

- pile-up,
- $\gamma$ -trigger,
- $\pi^0$  rejection.